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FAR U. V. DAYGLOW MEASUREMENTS: ATOMIC OXYGEN

by

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Baltimore, Maryland 21218

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NASA RESEARCH GRANT
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FOREWORD

This report is a manuscript of a paper which was presented at the Fifth International Space Science Symposium (COSPAR) in Florence, Italy, on May 14, 1964. The manuscript has been submitted for publication in Planetary and Space Science.

G. H. Dieke
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FAR U. V. DAYGLOW MEASUREMENTS: ATOMIC OXYGEN

Day airglow emissions of atomic oxygen in the ultraviolet have been previously reported (Chubb et al, 1958), (Heath and Fastie, 1962), (Donahue and Fastie, 1963), (Fastie, Crosswhite and Heath, 1964). The last results reported above were obtained at Wallops Island, Virginia, on May 7, 1963. Later results, reported herein, were obtained at Wallops Island on November 12, 1963 at 1900 G. M. T. In this latest experiment, the 1304A group ($^3S_1$ to $^3P_{0,1,2}$) (Fig. 1) were again measured as a function of altitude with a spectral resolution of 20 A and also with a resolution of 1.6 A. In addition the 1641A line ($^3S_1$ to $^1D_2$) was scanned.

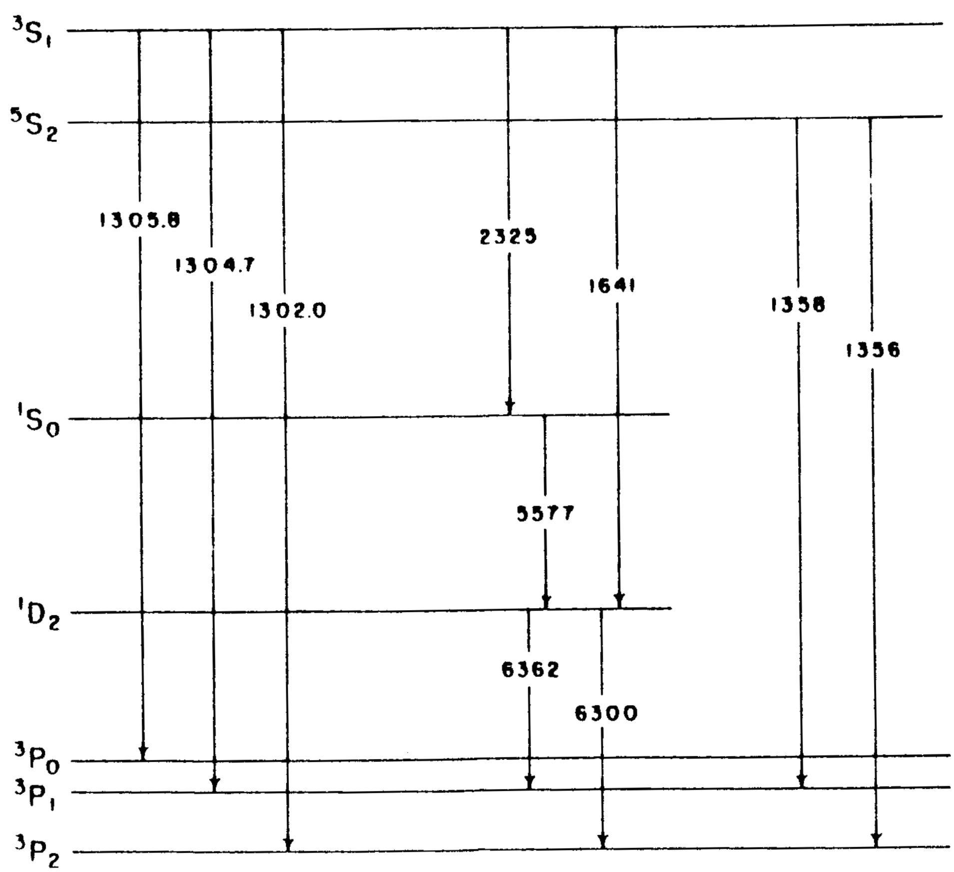

Figure 1. Energy Level Diagram for Atomic Oxygen.

This experiment was designed to obtain additional information about the radiative transfer process in atomic oxygen. The previous measurements had shown a decrease in the 1304A radiation above 185 km whereas radiative transfer calculations (Donahue and Fastie, 1963) have shown that such a falloff is not expected if the source is multiply scattered resonance reradiation of solar input at 1304A. They have suggested a source at 175 km due to dissociative recombination as one possible way to explain the observed peak. Subsequently, Fastie et al (1964) have pointed out that the observed high altitude drop-off would be expected if the f values for the transition from the $^3S_1$ level to the ^3P levels were somewhat larger than the calculated value (Garstang, 1961), (Kelly and Armstrong, 1964) or the measured value (Prag and Clark, 1964). A larger f value would increase the wing absorption due to the natural line width relative to the absorption due to the Doppler line shape. If this effect were operative, the 1302A line of the resonance group would be expected to be stronger than the other two lines, and to vary sharply with altitude.

Experimental Equipment

The details of the instrumentation have been described previously, (Fastie, 1963). The spectrophotometer, shown mounted in an Aerobee nose cone in Figure 2, consists of $^1/_2$ meter Ebert optical system with a 25 cm diameter Al-MgF coated mirror, a 64 mm by 64 mm plane grating with 3600 grooves per millimeter, entrance and exit slits 30 mm long, and a cyclic motor driven cam to program the grating scan and the slits. The detector was a E. M. R. 542 G photomultiplier tube with a lithium fluoride window and a caesium iodide photocathode. A simple DC electrometer amplifier tailored the output signal to F. M.—F. M. telemetry equipments and a D. C.—DC transistorized converter provided approximately 2500 V to operate the photomultiplier tube at about 10^6 gain. The experimental package weighed about 35 lbs.

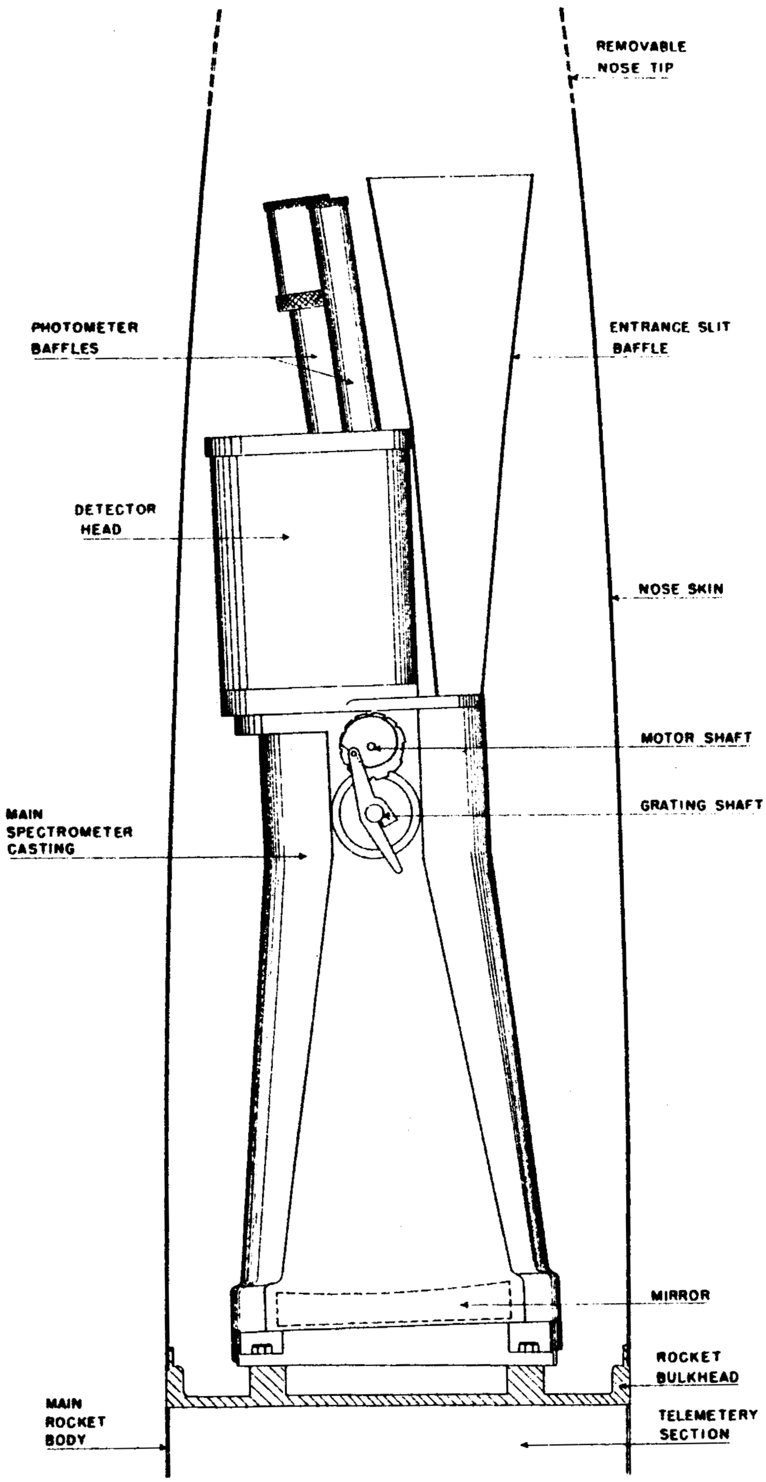

Figure 2. Ebert Ultraviolet Spectrophotometer Mounted in Aerobee Nose Cone with Tip Removed.

Experimental Results

1304 A Radiation

Figure 3 shows the altitude profile of the 1304 group at low resolution. The solid line was obtained on the May 7th flight. The circles and dotted line are the results of the November 12th experiment, normalized to the intensity at peak altitude of the earlier data. The new data shows a peak at slightly higher altitude than previously observed, but clearly reproduces the intensity falloff recorded in the May 7th flight. Both experiments were conducted under very similar quiet upper atmospheric conditions in the afternoon with a solar elevation of 30^0.

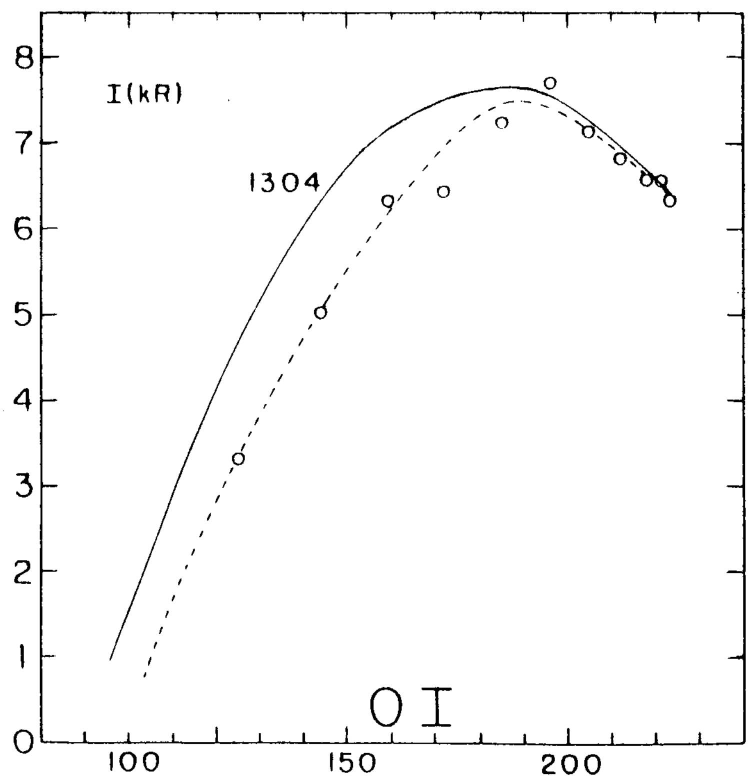

Figure 3. Height profile for 1304 A group. Solid line is May 7th flight. Dotted line and circles are November 12th results, normalized to peak altitude reading of May 7th flight.

The high resolution results lacked the high signal to noise evident in Figure 3. Figure 4 shows two spectral scans of the 1304 A group with 1.6 A resolution, at 190 km, and at 220 km. The dotted lines show the calculated profile for the geometrical slit width, assuming all three lines are equal in intensity. Within the experimental limitation of the wavelength drive and the slit programming mechanism (total estimated at $\pm$ 20%), these data indicate that the three lines are equal in intensity.

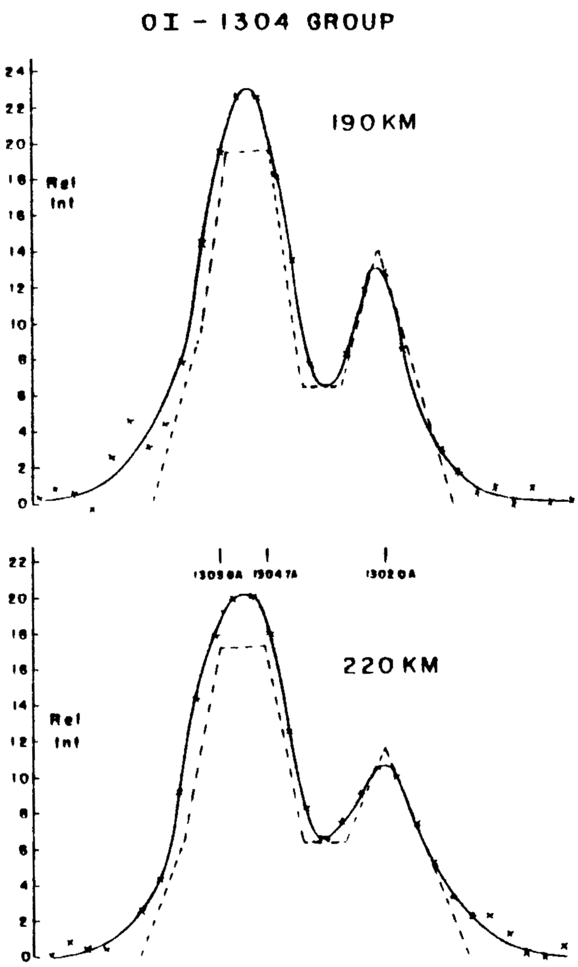

Figure 4. High resolution scans of 1304 group. Dotted lines are calculated from geometric slit width assuming all lines of equal strength.

More important, Figure 5 shows the measured ratio of the 1302 A line to the other two lines as a function of altitude. To an accuracy of $\pm$ 3%, the intensity ratio is invariant with altitude. To the above quoted limits, this experiment demonstrates that the radiative transfer problem can be adequately treated by assuming pure Doppler line width, and that absorption and reradiation in the far wings of the line do not play a significant role in the phenomenon.

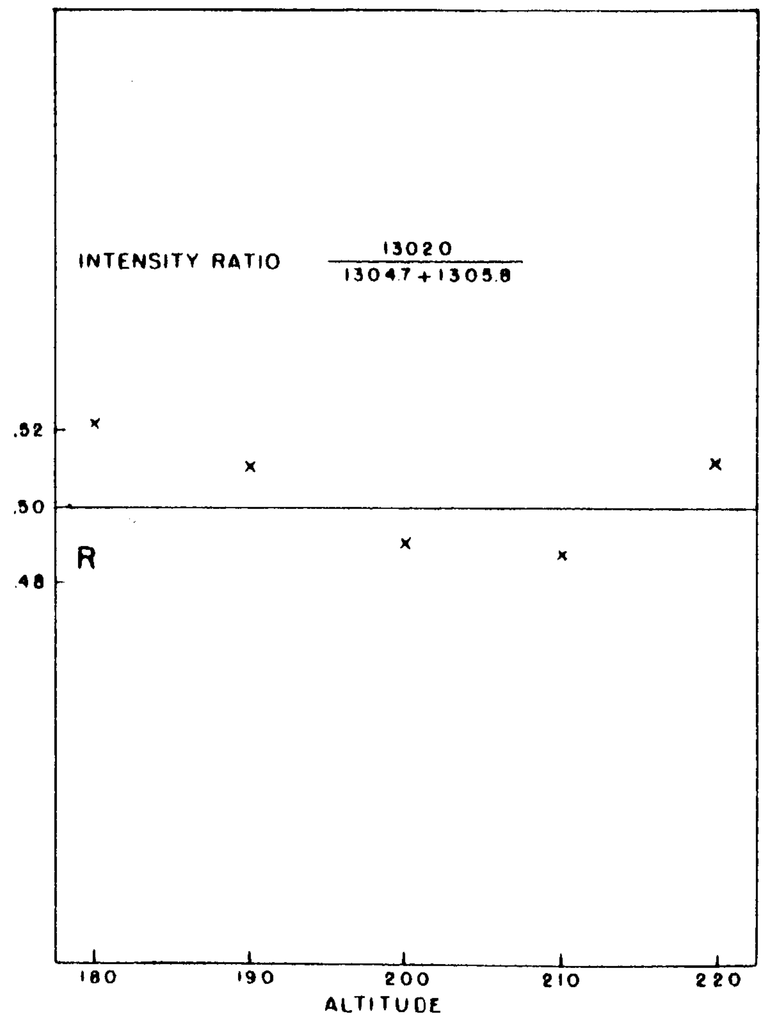

Figure 5. Intensity ratio of 1302 A line to 1304.7 plus 1305.8 A lines as a function of altitude (normalized to ratio of 0.50).

1641 A and 2325 A Radiation

In this latest experiment we also attempted to measure the 1641 A line of atomic oxygen ($^3S_1$ to $^1D_2$). In an experiment a few days later Barth (private communication) looked for the 2325 A line ($^3S_1$ to $^1S_0$). Neither of these lines was observed to a limit of 25 to 50 Rayleighs. These negative results mean that the above transitions are not significant factors in depopulating the $^3S_1$ state and do not have to be considered as loss factors in the radiative transfer analysis. Incidentally, these results also show that the 5577 dayglow (Wallace, 1964) and the 6300 dayglow (Zipf and Fastie, 1964) are not significantly fed by the above transitions.

CONCLUSION

The experiment described herein has answered several important questions about the behavior of oxygen atoms in the day airglow, but has not provided an explanation of the observed radiations. Present plans call for an experiment in a Javelin rocket in August, 1964, to trace the 1304 profile to an altitude of 800 km. This experiment is expected to further clarify the problem.

ADDENDUM

At the symposium at which these results were presented, S. A. Kaplan et al (1964) described photometer measurements of the unresolved 1304 A group which extended to 500 km. They found a similar low altitude peak as shown in Figure 3, which fell off to a plateau at 350 km, and which extended to the peak altitude of their experiment at about one-half the intensity observed at the 200 km level. The signal above 350 km is probably the contribution due to resonance reradiation of solar input at 1304 A.

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